Engineering Metrology

Program Manager: Jack A Stone
Total FTE: 7.5
Total Funding: $1,075,000

Goal

To guarantee industry access to world-class Engineering Metrology resources through (1) provision of measurement services, (2) development of new measuring techniques to address changing industry needs, (3) dissemination of metrology knowledge, and (4) standards activities.

Program Objectives

FY2003

Improve delivery of measurement services.

Timely provision of services

Provide SP-250 calibrations in a timely fashion to our customers, rebuild staff, and train new hires while maintaining present level of services.

Upgrade measurements of threaded gages

Validate API (American Petroleum Institute) software and procedures on Leitz coordinate measuring machine.

Gage blocks: Improving calibration efficiency

Develop and implement new procedures for penetration correction in order to retire half of our master gage blocks.

FY2002

Develop measuring systems and techniques for video-based metrology, for industry-needed metrology of flat-panel displays, and grid plates.

Video systems metrology

Develop prototype facility and procedures for investigating accuracy of video-based metrology systems.

Video-based Coordinate Measuring Machines (CMM) measurements

Develop video-based metrology system by integrating camera with new Moore M48 operating system.

High-Accuracy Two-Dimensional Measurements

Develop an industry-consensus standard grid: oversee measurements by state-of-the-art measuring machines in private industry and verify using NIST capabilities.

FY2004

Develop new tools or techniques needed for critical three-dimensional (3D) geometry measurements in discrete-parts manufacturing.

Small-hole geometry

Critical review and comparison of possible technologies for measurement of small holes (<1 mm) or fiber ferrule geometry.

Cylindrical form measurements

Develop fully characterized cylindricity measurement capability through integration of roundness and straightness measurement systems.

FY2001

Reduce demands on NIST resources by effectively disseminating dimensional metrology knowledge through development of web resources, seminars, and industry or other-agency interactions.

Dissemination of Engineering Metrology knowledge

(a) Implement web-based resources such as EMG FAQ (Engineering Metrology Group Frequently Asked Questions), calculations of deformation corrections, to be available on-line for our customers; (b) Offer workshop at Measurement Science Conference with updated class materials; and (c) Work with Army, Air Force, and Navy to upgrade their facilities and help them understand measurement needs.

Army Dimensional Calibration Support Hierarchy

Review the US Army Dimensional Calibration Support Hierarchy to improve the efficiency, accuracy, and implementation of the system of length measurement at all levels including field and non-environmentally controlled sites.

FY2002

Ensure that national and international standards provide value to US industry through demonstrable involvement in standards writing committees.

Engineering Metrology standardization efforts

(a) Send out American Society of Mechanical Engineers (ASME) gage block standard for vote;

(b) Send out ASME laser interferometer standard for comments; and

(c) Serve on other national and international committees- including Consultative Committee for Length (CCL) of the Bureau International des Poids et Mesures (BIPM), Technical Committee (TC) 213, and numerous other ASME committees (e.g., gage blocks, ring gages, plug gages, laser interferometers, optical polygons, and gear metrology) by providing all requested input and, where appropriate, conducting testing.

FY2002

Insure national and international confidence in measurements through significant involvement in measurement intercomparisons and support of the Mutual Recognition Arrangement.

Supporting international confidence in measurements

Support the Mutual Recognition Arrangement through acting as pilot lab for CIPM (International Committee of Weights and Measures) key comparison in diameter measurements, participation in other international comparisons as they become active (such as angle comparison), service on BIPM's Consultative Committee for Length; for quality effort, archive written procedures for at least three SP-250 calibrations.

Customer Needs

Engineering Metrology includes a variety of length and geometric measurements of objects with characteristic dimensions that range from a fraction of millimeter to more than a meter. This program supports national and international manufacturers, research and calibration facilities, standards writing organizations, and academia. Our principal commercial customers are the automotive, heavy equipment, telecommunications, and aerospace industries. The needs of these customers fall into three categories: (1) traceable measurements and standard reference materials with the lowest attainable uncertainty, (2) development of new techniques to improve and extend measurement capabilities, and (3) the latest, most accurate technical guidance on measurement related issues.

Provision of world-class measurement services is important to our customers. Artifacts calibrated by the Manufacturing Engineering Laboratory's (MEL) Precision Engineering Division provide a very direct path of traceability of industry measurements to the international standard of length. The calibrated artifacts are used as measurement reference standards to ensure that the dimensions of manufactured parts meet their design specifications. When manufactured parts conform to their design specifications - and such conformance is verified by traceable measurements - they work better, last longer, can be properly assembled with parts manufactured at other companies throughout the nation and the world, and can meet ISO 9000 requirements for international trade. NIST annually calibrates over 5000 dimensional artifacts for over 160 organizations in 40 states. NIST calibrations are the keystone in assuring traceable measurements for the US discrete-parts manufacturing sector.

The new global economy requires that NIST continuously improve our dimensional measurement capabilities to satisfy the demands of ever-tightening tolerances and to maintain parity with other national measurement institutes. The verifiable accuracy with which a part or instrument can be sold in the international marketplace will in some cases depend on the uncertainty of our calibrations, and therefore it is important that these calibrations be delivered with best-in-the world capabilities.

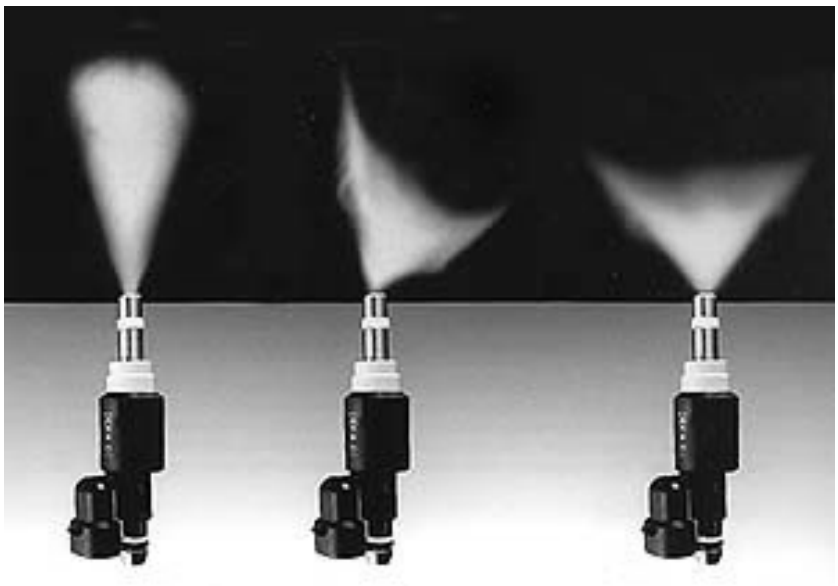
New measurement techniques developed here and improvements in our internal measuring capabilities will have direct economic benefits for our customers by allowing them to explore areas of design and development previously unapproachable due to measurement limitations. For example, industry needs improvements in our capability to measure the diameter and form of small holes (such as optical fiber ferrules or fuel injectors) and in measurement of cylindrical artifact geometry (also a limiting factor in the uncertainty of the NIST realization of the derived unit of pressure). We also need to develop new measuring techniques to improve the efficiency with which we can deliver existing measurements— thus, for example, we have a research program aimed at drastically reducing the effort required to maintain our gage block measurement service.

Finally, our customers depend on national and international standards to facilitate commerce through standardization of testing and calibration procedures. Equipment customers rely on standards to specify industry-wide uniform testing procedures, making it easier to compare products.

Technical Approach

This program is a broad approach to improving all aspects of Engineering Metrology services to industry. Key elements of our technical approach are summarized here.

Delivery of measurement services and dissemination of technical information will be improved by: (1) upgrading current measurement services through the use of new or refined state-of-the-art techniques and equipment resulting in lower measurement uncertainties and greater efficiency in service delivery, (2) working toward providing new standard reference materials, (3) being actively involved in measurement intercomparisons and standards writing committees, (4) documenting measurement procedures and techniques, (5) refining current educational seminars and implementing new ones, and (6) providing convenient access to information on the web.



Example of critical small hole features: fuel injectors

We are carrying out research ranging from basic investigations to applied research and development to improve our own measurement processes and to develop industry-needed processes. One approach will use a matrix of newly developed technology, measurement techniques, algorithms, software, and strategically designed hardware modifications to extend the capabilities of existing Engineering Metrology dimensional measurement instruments beyond the current state of the art, or to their practical limits. The immediate goal for this effort is to lower measurement uncertainty, expand measurement range, and increase measurement efficiency.

A second approach is to better integrate measurement systems so as to increase their efficiency and lower their measurement uncertainty. One strategy is to better integrate the functions of data acquisition with analysis. Where possible, measurement data and analysis results should be made to be compatible with standard desktop software applications. A second strategy is to integrate separate measurement operations into one system. The current project to upgrade the Talyrond roundness measuring system to integrate digital straightness measurements combines two previously separate elements of cylindricity measurement. Our Moore M48 measuring machine serves as the foundation of several projects above that fully utilize its intrinsic flexibility.

Standards Participation

- American Society of Mechanical Engineers (ASME) Committee on Gear Metrology: member
- ASME B89: Dimensional Metrology: member
- ASME B89.1.17 Thread Wire Measurement: member
- ASME B89.1.2 Calibration of Gage Blocks by Mechanical Comparison: member
- ASME B89.1.5 Measurement of Plain External Diameters for Use as Master or Cylindrical Plug Gages: member
- ASME B89.1.6 Measurement of Qualified Plain Internal Diameters for Use as Master Rings and Ring Gages: member
- ASME B89.1.8 Laser Interferometers: member
- ASME B89.1.9 Gage Blocks: Chair
- ASME B89.3.1 Roundness: member
- ASME B89.5 Vocabulary: member
- ASME B89.7 Measurement Uncertainty: member
- Consultative Committee for Length (CCL) of the BIPM (Bureau International des Poids et Mesures): member
- ISO Technical Committee (TC) 213 Working Group (WG) 6 General Requirements for Geometric Product Specification (GPS) Measuring Equipment: Convener and Secretary
- Working Group on Dimensional Metrology of the CCL: SIM (Interamerican System of Metrology) representative to working group.

Accomplishments

- October FY2000 Volumetric performance test of our Moore M48 Coordinate Measuring Machine (CMM) indicates that this CMM is among the most accurate in the world. To our knowledge, the result of our volumetric performance test (420 nm) is the best that has ever been reported for a machine of comparable size.
- October FY2000 Using our newly developed micrometer, diameter measurements were made of a set of ultra-thin nickel-alloy fibers, only 13 micrometers in diameter—the thinnest cylindrical artifacts ever measured by EMG. The measurement represents EMG response to new and expanding traceability requirements of emerging industries.
- September FY1999 An integrated cylindricity measurement system has been designed and constructed in cooperation with Metrex Inc. Hardware is complete— ready to start software testing.
- September FY1999 Finished testing on AAMACS (Advanced Automated Master Angle Calibration System), the world's highest accuracy angle measuring system, following a re-design and rebuilding effort in cooperation with A.G. Davis.
- September FY1999 A proposed standard reference material (SRM) for grids for the semiconductor industry has been developed, and measured on three industry measuring machined and the NIST linescale. Proposed changes from industry participants are being incorporated into a new design.
- September FY1999 Completed calibrations of more than 5000 artifacts for more than 120 customers during FY1999.
- October FY1998 Completed participation in the CCL (Consultative Committee for Length) Key Comparison in Gage Blocks. Our role involved length measurement of 20 gage blocks using static interferometry. The measurement process involved independent measurement of the interferometric phase correction of each gage block, the initial determination of the deviation from nominal for each block by mechanical comparison, independent verification of temperature, pressure, and relative humidity sensors, uncertainty calculation according to CCL Protocol, and reporting of the results and their associated uncertainties according to CCL Protocol. The interferometric phase correction is the correction applied to compensate for phase change of the light on reflection from the gage block surface. The agreement of these measurements with other international participants will be used to determine international equivalence between NIST and other participating countries in gage block length measurement.
- October FY1998 Completed measurements on two out of three gear artifacts, which are a part of a complex form intercomparison organized by the British Gear Measurement Center at the University of Newcastle. When completed, this intercomparison will provide a measure of agreement between U.S. Gear Manufactures, the international community, and NIST.
- October FY1998 Completed measurement process and software evaluation of the NIST designed laser micrometer used for mechanical comparison measurement of customer thread wires, cylinders, plug gages, and pin gages. This new system provides a larger measurement range, precise force control, and eliminated the maintenance of several hundred masters previously required.

- October FY1998 Participated in an EUROMET international intercomparison for measuring the optical phase change correction for gage blocks. The newly developed instrument for measuring this parameter was used.
- October FY1998 Completed the following customer calibrations in fiscal year 1998: (5615) Gage Blocks by Mechanical Comparison, (123)* Gage Blocks by Interferometry, (224)* Angle Blocks, (18)* Optical Flats, (706)* Thread Wires, (173)* Balls, (11) Sieves, (37)* Ring Gages, (7) Roundness Standards, (81) Cylindrical Diameter Standards, (233) API Gages, and (241) Miscellaneous Items. Calibration charges totaled approximately $417 K; this excludes calibration program fees and surcharges. * Indicates an increase in the number of items calibrated relative to 1997 fiscal year figures.

FY2000 Measurement Services

Calibrations

- (10010C-10015C) Gage Blocks
- (10060S) Sieves
- (10010S-11014S) Cylindrical Diameter Standards
- (11020C-11021C) Thread Wires
- (11030S-11034S) Spherical Diameter Standards
- (11040S-11041S) Plain Ring Gages
- (11060S) Step Gages
- (12010C-12042C API Gages
- (12050S) Threaded Plug and Ring Gages
- (12060S) Two Dimensional Gages
- (12070S) Complex Dimensional Gages
- (13010S-13014S) Optical Reference Panes (Flats)
- (13020S-13030S) Roundness
- 14010C-14011C) Angle Blocks
- (14020S) Polygons
- (14030S-14031S) Indexing Tables
- (14040S-14041S) Optical Wedges
- (14050S) Special Angular Measurements
- (14510S-14511S) Laser Frequency or Wavelength

SRMs

- SRM 2522 Pin Gage Standard for Optical Fiber Ferrules
- SRM 2523 Optical Fiber Ferrule Geometry Standard
- SRM 2553 Optical Fiber Coating Diameter (n=1.504)
- SRM 2554 Optical Fiber Coating Diameter (n=1.515)
- SRM 2555 Optical Fiber Coating Diameter (n=1.535)

API measurement on Leitz CMM